

# Energy Selects

## Plasma, Plasmonics, and Perovskites

We're very pleased to introduce a new feature called *Energy Selects* as part of our *Energy Focus* portfolio, of which this is the inaugural article. Our Editorial Advisory Board members will periodically highlight some of the key papers published in each issue of *ACS Energy Letters*. In this issue, Prof. Bryan McCloskey, Prof. Lioz Etgar, and Prof. Csaba Janáky have chosen the following articles as notable advancements in the field and have discussed the importance of each to the area of catalysis and perovskite photovoltaics. In addition to Editors' Choice articles chosen by ACS publications, the *Energy Selects* will provide our readers new developments specifically in the energy research.

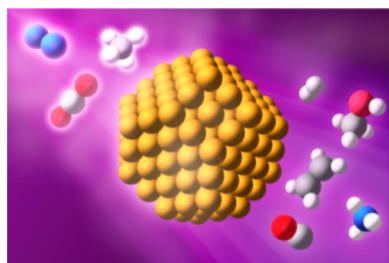
### ■ CATALYSIS ENABLED BY PLASMA ACTIVATION OF STRONG CHEMICAL BONDS: A REVIEW

Prateek Mehta, Patrick Barboun, David B. Go, Jason C. Hicks, and William F. Schneider

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DOI: 10.1021/acsenerylett.9b00263

Link: <https://pubs.acs.org/doi/10.1021/acsenerylett.9b00263>



In the current issue, Mehta et al. provide an excellent review on enabling challenging chemical conversions through plasma activation. Improving the efficiency and selectivity of abundant feedstock conversion to value-added chemicals would reduce the energy requirements necessary for many major chemical processes. However, many low-cost or freely available feedstocks—examples highlighted by Mehta et al. include nitrogen, carbon dioxide, and methane—are inherently unreactive and require high temperatures and pressures over exotic catalysts to allow modest thermal conversion to desirable products. As an alternative, Mehta et al. describe the use of near-ambient temperature and pressure plasma discharges to access rates and selectivities of  $N_2$ ,  $CO_2$ , and  $CH_4$  conversion that would not be possible using thermal catalysis alone under similar conditions. The authors discuss mechanisms for plasma-driven bond activation, emphasizing the ability of plasma discharges, particularly in the presence of heterogeneous catalysts, to activate even the strongest covalent bonds (e.g., the nitrogen–nitrogen triple bond). They then provide a useful and extensive comparison of thermally driven and plasma-driven ammonia synthesis from dinitrogen and dry reforming of methane to form syngas. Their Review clearly outlines the promise that

plasma activation of molecules provides sustainable chemical production. As the field learns more about plasma/catalyst interactions, further enhancements in conversion rates and selectivity, or the ability to access pathways to new products, could provide plasma chemistry with a compelling advantage over thermal chemistry at lower operating temperatures and pressures.

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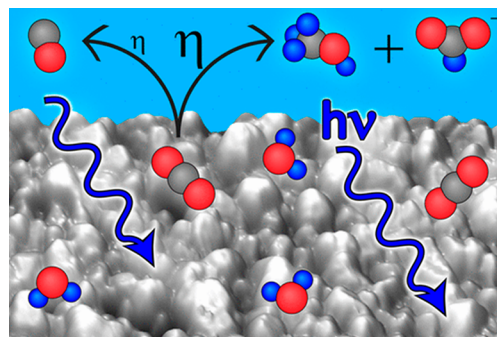
### ■ DIRECTING SELECTIVITY OF ELECTROCHEMICAL CARBON DIOXIDE REDUCTION USING PLASMONICS

Erin B. Creel, Elizabeth R. Corson, Johanna Eichhorn, Robert Kostecki, Jeffrey J. Urban, and Bryan D. McCloskey

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DOI: 10.1021/acsenerylett.9b00515

Link: <https://pubs.acs.org/doi/10.1021/acsenerylett.9b00515>



Plasmon-induced hot carriers are generally considered to be too short-lived to facilitate chemical reactions, simply because of the mismatch of the time scale of the two processes. In the Letter from McCloskey et al., the plasmon-enhanced *electrochemical* reduction of carbon dioxide is demonstrated on silver electrodes. Their recent cell development efforts allowed control of the macroscopic temperature of the cell, thus excluding trivial temperature effects. A remarkable enhancement was obtained in the  $CO_2$  reduction performance (both activity and selectivity) at moderate cathodic bias potentials. Moreover, methanol appeared as a new product when illuminating the electrode with monochromatic light matching the plasmon band of Ag. This is a particularly interesting observation as the formation of methanol requires six electrons and protons! Another intriguing finding of this study is the *absolute* decrease of the hydrogen evolution activity of the silver electrode under illumination, although the reasons

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behind this trend still have to be uncovered. Notably, this study is fundamentally different from those carried out on particulate suspensions (showing very little effect of plasmonic electrons on the reduction performance) in the absence of electrochemical bias. Clearly, this paper will inspire researchers to scrutinize this effect carefully with different electrocatalyst materials, which also show plasmonic behavior. In my opinion, operando time-resolved pump–probe laser spectroscopic measurements under electrochemical control might provide new insights in the charge carrier dynamics and thus the overall mechanism of the process.

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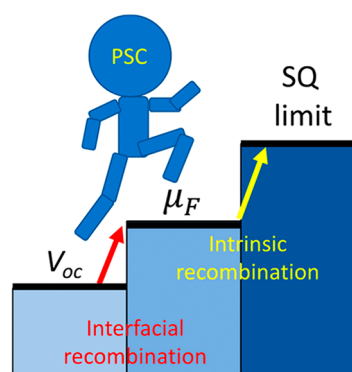
### ■ COMPARING THE CALCULATED FERMI LEVEL SPLITTING WITH THE OPEN-CIRCUIT VOLTAGE IN VARIOUS PEROVSKITE CELLS

Dengyang Guo, Valentina M. Caselli, Eline M. Hutter, and Tom J. Savenije

*ACS Energy Lett.*, 2019, 4, 855–860.

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One of the significant advantages of metal halide perovskite is its ability to gain high open-circuit voltage ( $V_{oc}$ ) in a single-junction solar cell. To date, perovskite-based solar cells can achieve a  $V_{oc}$  of more than 1.2 V for a band gap of 1.55 eV. However, this is still below the maximum  $V_{oc}$  of 1.33 V due to its band gap and thermal radiation. In my opinion, understanding the factors that govern the  $V_{oc}$  could open a way for improved performance in these solar cells as well as answering fundamental scientific issues. In this work, the authors calculate the rate constants and the mobilities from time-resolved photoconductivity measurements in order to find the limit of the  $V_{oc}$ . The highlight of this paper shows that the interfacial recombination processes are not necessarily the main limiting factor of the  $V_{oc}$ , while the decay processes occurring inside of the perovskite layer are limiting the  $V_{oc}$ . It is suggested that increasing the  $V_{oc}$  can be achieved by light soaking and the addition of  $\text{Cs}^+$  and  $\text{Rb}^+$ ; moreover, improving the transport layers that will decrease the recombination at the interface will result in a high  $V_{oc}$ .

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#### Notes

Views expressed in this energy focus are those of the author and not necessarily the views of the ACS.

The author declares no competing financial interest.